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SERI-RES를 이용한 Radiant Floor Heating System의 열 성능 분석

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A Thermal Performance Analysis on the Operation Modes of Radiant Floor Heating System Using SERI-RES

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요 약

본 연구는 일차원 열 성능 분석 프로그램인 SERI-RES를 이용하여 우리 고유의 난방 방식이라 할 수 있는 Radiant Floor Heating System의 운전 모드(Operation Modes)에 대한 시뮬레이션을 수행하였다. SERI-RES는 원래 공기 가열식 시스템을 주요 난방 방식으로 작성된 프로그램이라 본 연구의 시뮬레이션을 수행하기 위하여 Source Code에 대한 약간의 수정을 가하였다.

얻은 결과를 분석하여 보면 Radiant Floor Heating System은 그 운용 방법(Operation Modes)에 따라 건물의 동적 열 성능에 상당한 영향을 미치는 것으로 나타났으며 이는 Test Cell에 대한 간단한 실측 실험을 통해서도 확인되었다.

SERI-RES는 비록 HVAC시스템등에 대한 구체적인 시뮬레이션은 불가하나, 비록 일차원적이기는 하지만 Radiant Floor Heating 시스템과 건물의 동적 열 성능에 대한 분석에는 상당히 효율적인 Simulation Model을 제공하였다.

ABSTRACT

The present paper deals with two types of heating methods widely used for the Radiant Floor heating systems in Korea. Of these, one method circulates hot water according to the predefined schedule ("intermittent heating") while the other runs the system with the aid of thermostats ("continuous heating"). The standard version of SERI-RES has been modified for the numerical simulation of the problem. Preliminary results show relatively large temperature swings in the case of intermittent heating with solar availability. On the other hand, the case of continuous heating would avoid such undesirable temperature fluctuations. These results are also verified by experimental evaluations.

1. INTRODUCTION

In Korea, it has long been a problem to reduce the staggering consumption of petroleum--based energy used for space heating in buildings. Considerable attention and effort have been directed in this area for decades. The motivation behind the research described in this paper was to obtain the most efficient way of implementing the Radiant Floor heating system for residential buildings where space heating is furnished by coils carrying got water imbedded in the massive floor. Fig. 1 shows the floor section of the building structure that is heated by the Radiant Floor heating system.

Our major interest here was with large apartment buildings where central heating is provided.

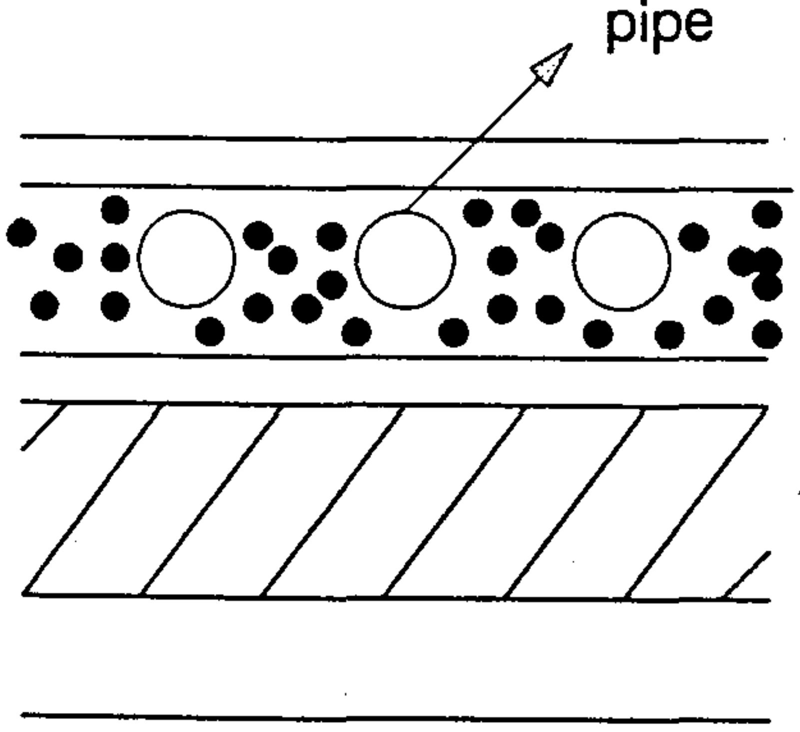

Fig. 1 Floor section

Two types of methods are studied for their thermal performances in operating the Radiant Floor heating system. These two methods differ, essentially, by the manner hot water is being circulated through the system. Of these, one called the "intermittent heating" is furnished by circulating hot water through coils two or three times a day for a period of 2 or 3 hours each time on a fixed schedule. The other, called the "continuous heating" method runs hot water upon demand from the thermostat installed in a room so that continuous space-conditioning is attained.

2. NUMERICAL ANALYSIS

It is most important to properly simulate the thermal response of the massive floor through which heat is supplied for the accurate thermal performance evaluation of the whole system. In the present study, the standard version of SERI-RES has been modified for our purpose since there is a significant time delay as well as thermal storage considerations that cannot be adequately modeled if air heating simulation is directly applied. The standard version of SERI-RES is programmed to provide heating and cooling to the air node of a zone upon demand from the thermostat installed in that zone. Here a zone refers to either a room, or group of rooms that operates at the same temperature.

2.1 NUMERICAL MODEL

Each apartment unit is treated as consisting of four zones: the living zone, the buffer zone, and two "artificial" zones-the heating coil zone under the living zone, the heating coil zone under the buffer zone. This configuration is taken to minimize the source code modifications and to accomplish our objective of simulating the thermal behaviour of an apartment unit heated by the Radiant Floor heating system. The modifications are designed for the purpose of heating with no venting or cooling for the four zone problem aforementioned in the absence of any rockbeds or fans.

Heat is added to the arificial zones and transferred into the living and buffer zones with appropriate time delay and storage effects. Source code modifications of the SERI-RES are made in this regard, since manipulating input files alone could not reflect the heat transfer mechanism involved in the Radiant Floor heating system. For the case of continuous heating method, heat is supplied to the artificial zones when required by a thermostat installed in the living or buffer zone.

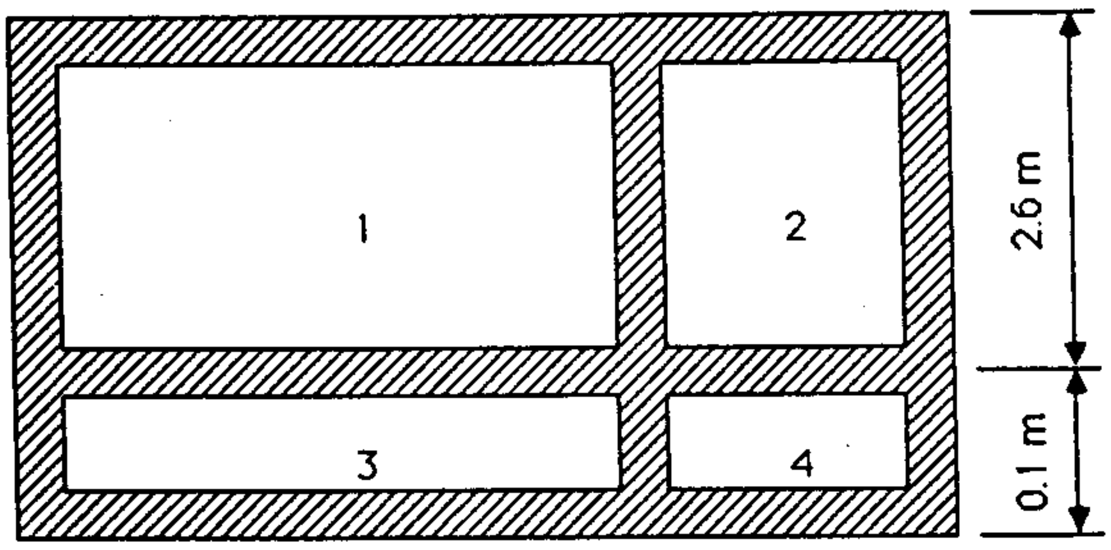

Fig. 2 Numerical model of an apartment unit. 1. living zone, 2. buffer zone, 3. heating coil zone, 4. heating coil zone

2.2 ASSUMPTIONS

Even though the numerical technique is one of the very few acceptable tools that is capable of handling many real world problems, it requires both physical assumptions and mathematical approximations for a given physical problem. In the present analysis, a number of specific assumptions are made apart from those of the SERI-RES. The followings are the key assumptions:

- Artificial zones have no infiltration or solar gains and all surfaces have high surface conductances with zone air.
- In simulating any particular unit, a symmetry plane is assumed which is adiabatic.
- The Stones above the coils were approximated by a slab with twice the conductivity compared to the stones below the coil. This permits more heat transfer in the upward direction compared to the downward direction.
- The thermal conductance between the living and buffer zone is 150W/℃, which is about 5 air changes per hour.
- The desired indoor temperatures for the living and the buffer zones are 20℃ and 18℃, respectively.

3. EXPERIMENTAL EVALUATIONS

An experimental building has been built to compare the computed results qualitatively a quantitatively with the experimental values. Desk of the building complies with the thermal model an apartment unit considered in the prese analysis. Fig. 3 shows the floor plan of the building.

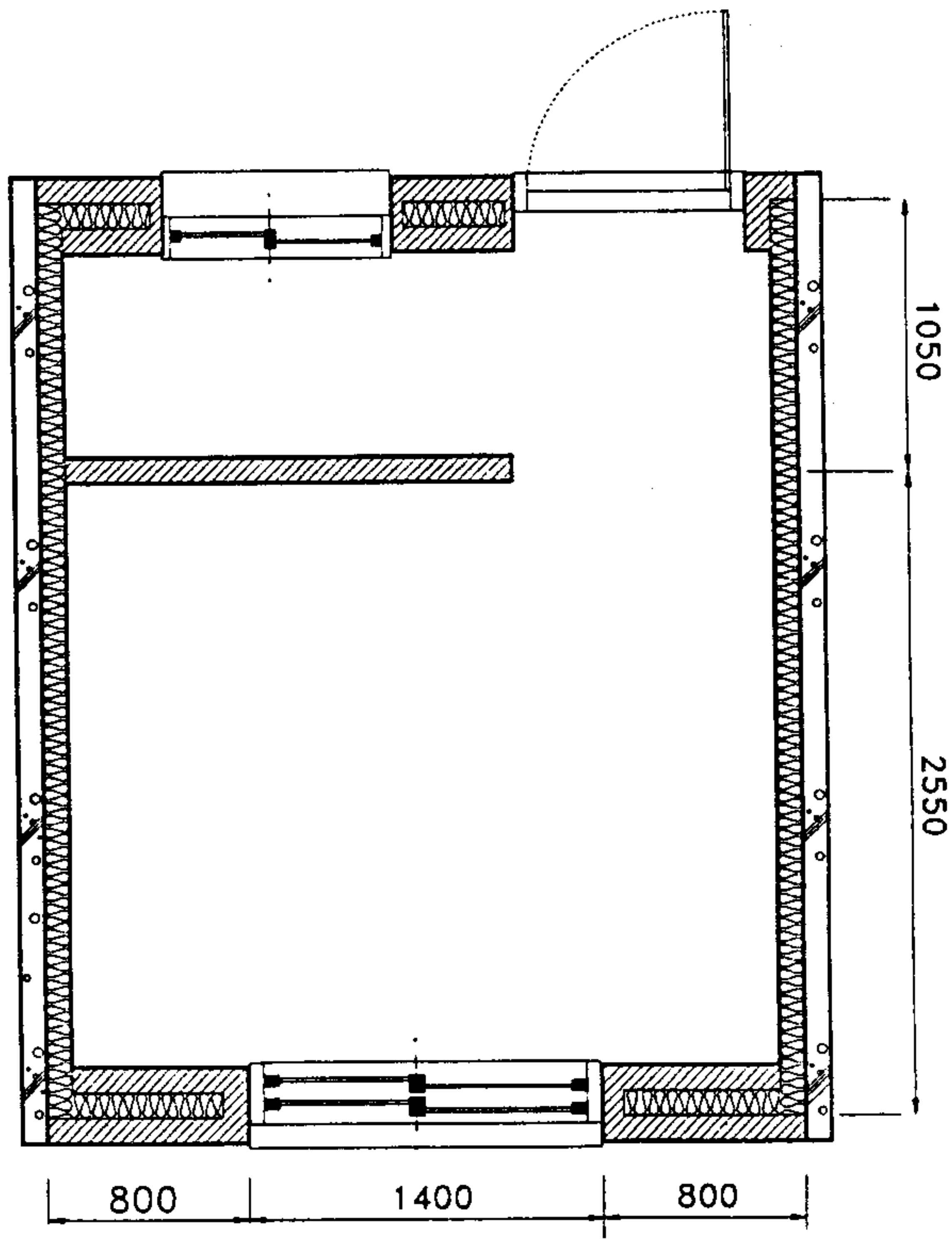

Fig. 3 Floor plan of the experimental building

It is built mainly with concrete and cement bricks. Polystrene is used for insulation. The east and west side walls include 150mm concrete, 70mm polystrene and 9mm plywood. The south and north side walls are composed of 24mm cement mortar, 90mm brick, 70mm polystrene, 90mm brick and 9mm plywood. Roof layers are 70mm cement mortar, 50mm polystrene, 120mm concrete. 20mm polystrene and 9mm plywood. The flooring consists of 120mm concrete, 20mm polystrene, 30mm mortar, 60mm stones and 40mm mortar. A 1.35m^2 double glazed window is constructed in the south-facing wall whereas a 0.81m² window is fixed in the north-facing wall. A partition wall divides the building into two zones: living and buffer zones. The partition wall consists of 24mm cement mortar, 90mm brick and 6mm tile. Part of the partition is provided with a slide curtain to suppress the interzone heat transfer. A 1.89m² door is placed on the north wall.

4. DISCUSSION OF RESULTS

The modifications made to the standard version of SERI-RES in the present analysis have been examined to insure the accuracy of predicted results. Many test runs were made with various diagnostic checks. It seems that a number of assumptions taken in the formulation of the SERI-RES don't have a major impact in simulating the thermal model of heating methods for the radiant floor heating system. A series of inputs(building description files) are prepared to simulate thermal perfomances of an apartment unit under different operating conditions. The Seoul (latitude: 37.6°N) and Daejeon(latitude: 36.4°N) weather files are used for the analysis.

Much of the heat flow between the living and buffer zone appears to take place through partition walls. Sensitivity study shows little change in indoor temperature of each zone with the variation of interzonal air flow between the zones. The cases tested range from zero to 150 W/℃(5 air changes per hour) in the equivalent conductance values, which accounts for the heat transfer between the zones by air flow.

The number of nodes used in the calculation of temperature for each wall layer had little influence on the outcome of simulation for the proposed thermal model. In most runs, one node was used for all layers. Using more than one node for a layer might be appropriate for certain materials with high thermal mass if the computation time is not a serious limitation.

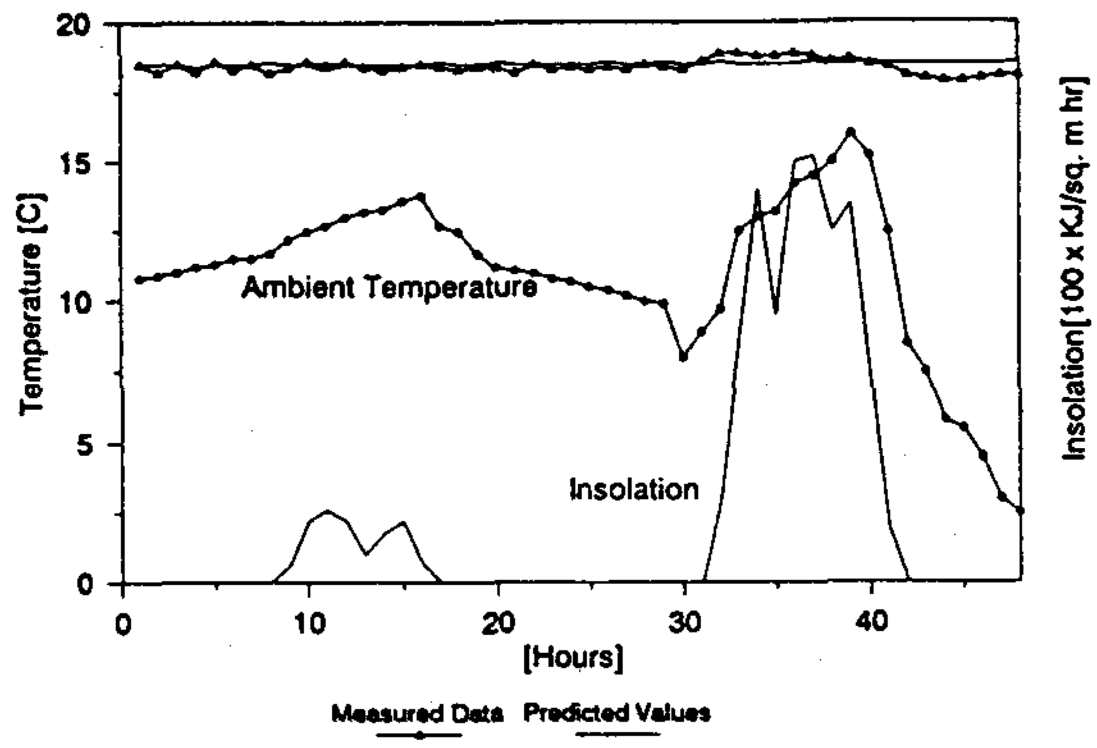

Fig. 4 A comparison on the predicted and measured values for the experimental building(continuous heating)

Fig. 4 compares the predicted values of SERI-RES with the measured data for the experimental building, when continuous heating is provided. Agreement is very satisfactory except the last few hours where it shows a sharp drop in the ambient temperature. This discrepancy is due to insufficient heating capacity of the boiler, which could not meet heating needs of these last few hours.

Fig. 5 presents a case of overheating in November. Here heating is provided 2 times a day for a period of 2 hours each (at 5 AM and at 5 PM) for intermittent heating. From the results shown it could be conjectured that a relatively large interior temperature swing is quite within the bounds of possibility in the case of intermittent heating depending on solar availability: overtheating during warm weather and underheating during cold weather conditions.

Fig. 6 compares the annual energy requirement of three different types of heating schemes to maintain the indoor temperature at the same level. It shows that the direct air heating system is the most energy efficient compared to the any of the two methods widely practiced for the Radiant Floor heating system. However, it is considered by many who experienced it, that the Radiant Floor heating system provides high-

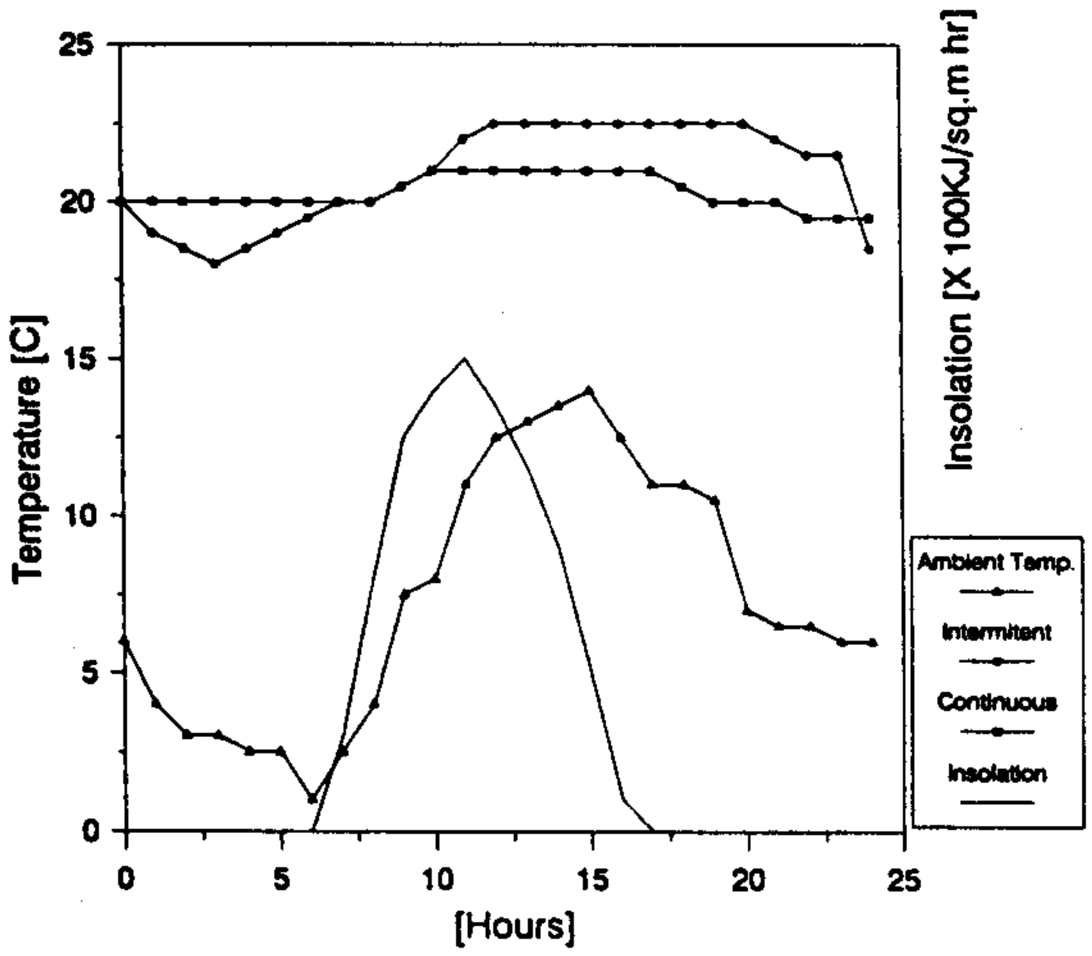

Fig. 5 A case of overheating in November

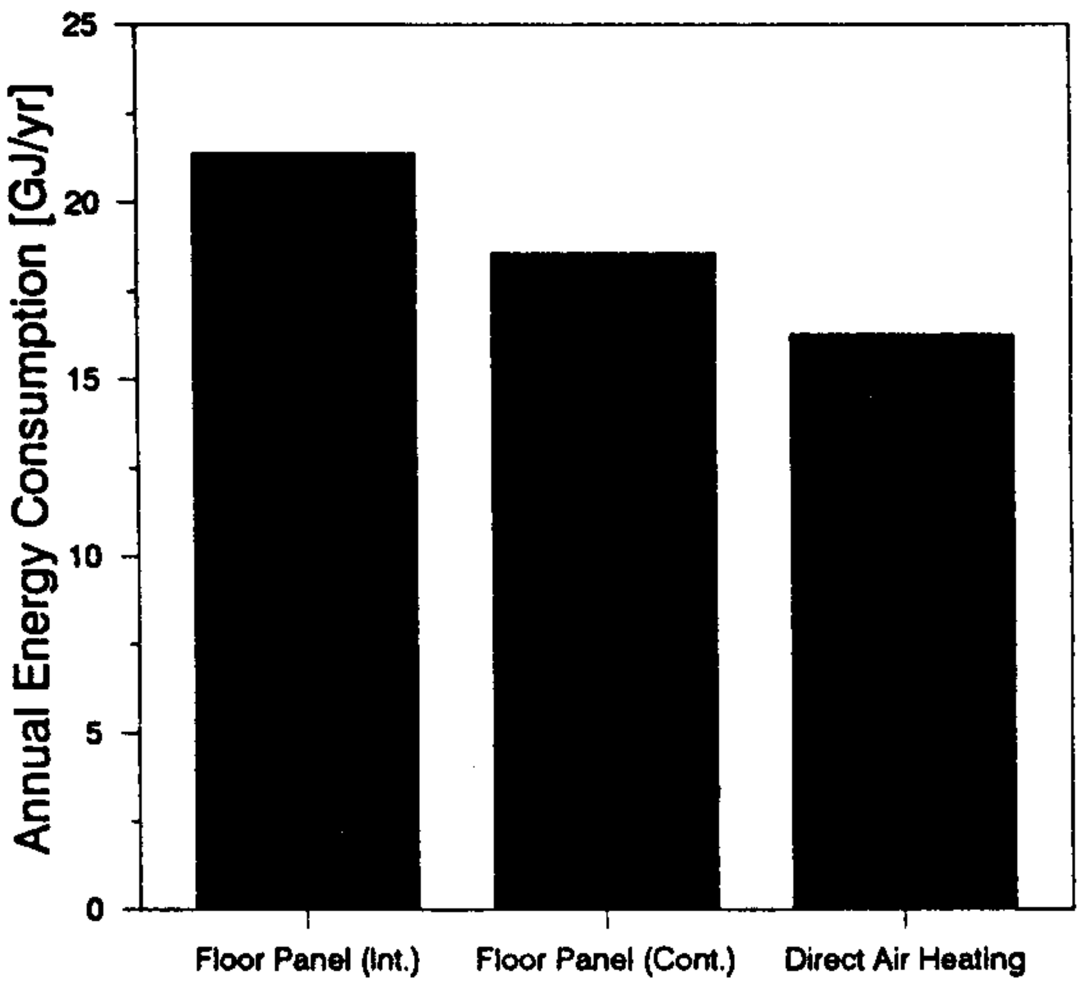

Fig. 6 A comparison of the annual energy consumption for three different types of heating schemes for an apartment unit per year

er quality in heating and more comfort than the direct air heating system.

5. CONCLUSION

The objective of this study was to investigate the thermal performance of two types of operating schemes for the Radiant Floor heating system in large apartment buildings. It was found that the continuous heating method was more stable and energy efficient over the intermittent heating method, which tends to show overheating during warm weather and underheating during cold weather conditions in a number of cases examined here.

6. ACKNOWLEDGEMENT

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ABSTRACT

The purpose of this paper is found consistent mathematical data of Inter–reflection of calculation as a mean to grasp characterises reflex of building materials that primarily uses in Building, and that comes in to the market. The measurement of directional charcteristics of non–metallic Building Meterials is based on seperation measurement of Boundary Reflected and Layer Reflected component using a Reflectmeter with Polarized. And this study analyzed with not only experiment but simulation to furnish basic data for illumination design to daylighting.

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Thermally Stratified Hot Water Extraction

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ABSTRACT

Thermal stratification enhancement for the higher extraction efficiency of hot water storage tank was experimentally studied with transparent fiber glass cylindical tank(350 ℓ, D=516mm, H=1680mm). Height to diameter ratio(H/D=1,2,3), flow rate(Q=8,10,12LPM), inlet–outlet temperature differences(ΔT=20,25,30℃), and geometry of inlet–outlet port were the parameters. In particular, three kind of distributors were used for geometry of inlet–outlet port. As a result, it was possible to get extraction efficiency of 95% by using the distributor having variable diameter but keeping a constant diameter of perforation. So it is recommendable to design the distributor so that the main pipe decrease in diameter toward the dead end.